#UKPHC21

CHOOSING A LOW CARBON HEATING SYSTEM

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Etude

What we will cover

Residential focus

- Types of heating system
- Key considerations: carbon, cost, etc
- Suitability to Passivhaus and benefits of high fabric efficiency

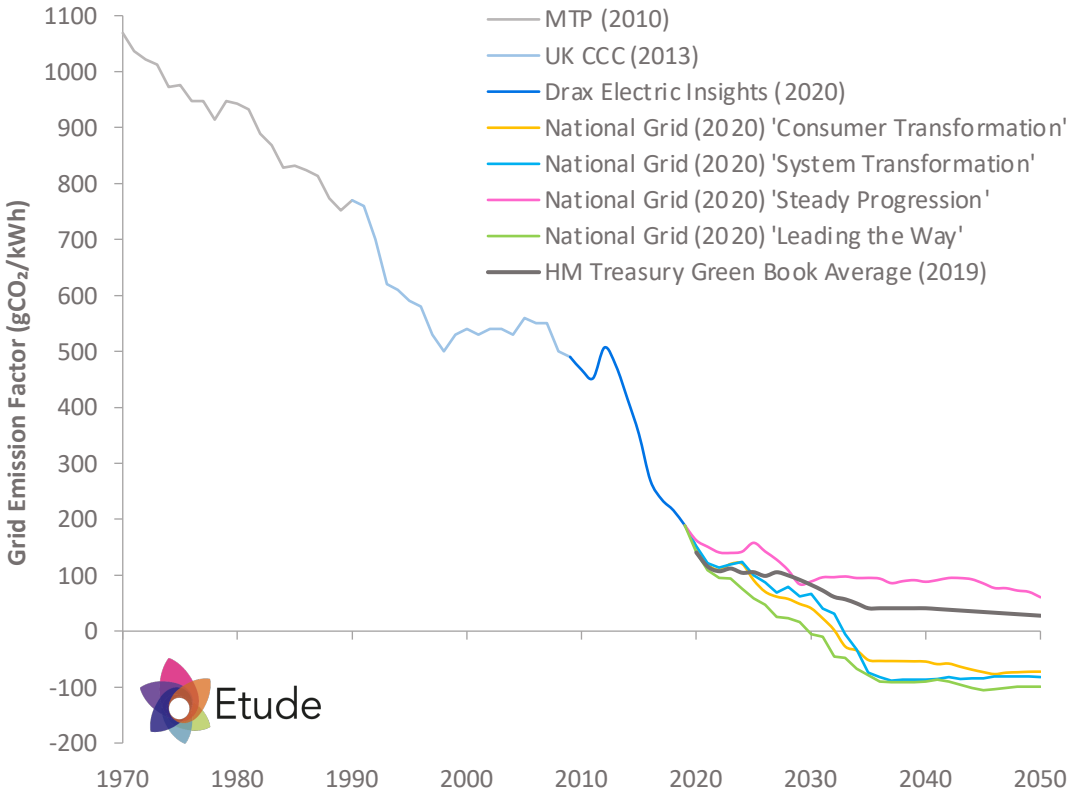
Away from gas

- No gas boilers in new UK homes from 2025
- International Energy Agency suggests no new fossil fuel boilers should be sold globally from 2025

To what?

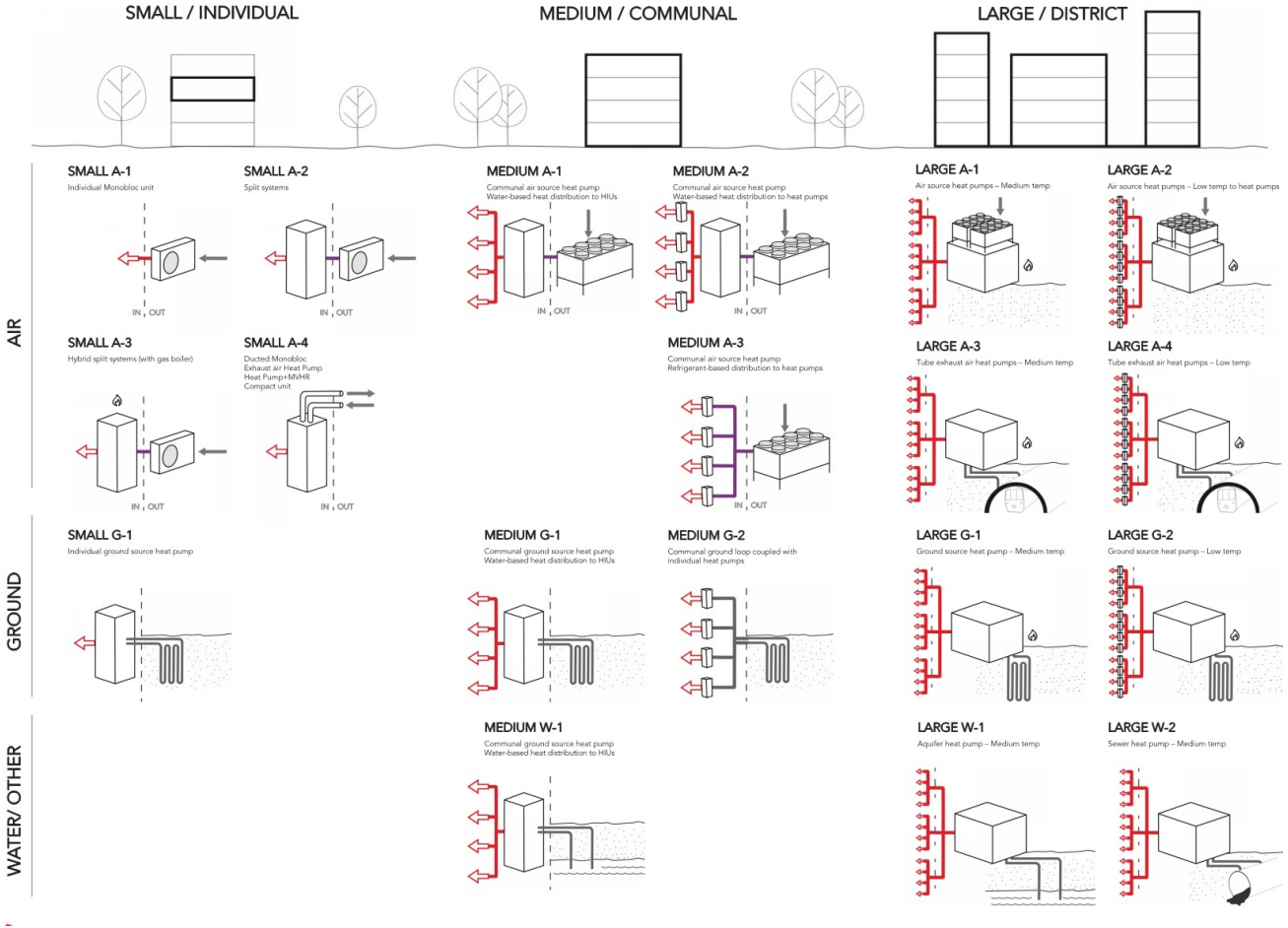
Electrification

- Heat pumps
- Direct electric



Long-term variations in emission factor of grid electricity

To what?


SMALL / INDIVIDUAL
MEDIUM / COMMUNAL
LARGE / DISTRICT
AIR
GROUND
WATER/ OTHER
SMALL A-1
Individual Monobloc unit
SMALL A-2
Split systems
SMALL A-3
Hybrid split systems (with gas boiler)
SMALL A-4
Ducted Monobloc
Exhaust air Heat Pump
Heat Pump+MVHR
Compact unit
SMALL G-1
Individual ground source heat pump
MEDIUM A-1
Communal air source heat pump
Water-based heat distribution to HIUs
MEDIUM A-2
Communal air source heat pump
Water-based heat distribution to heat pumps
MEDIUM A-3
Communal air source heat pump
Refrigerant-based distribution to heat pumps
MEDIUM G-1
Communal ground source heat pump
Water-based heat distribution to HIUs
MEDIUM G-2
Communal ground loop coupled with
individual heat pumps
MEDIUM W-1
Communal ground source heat pump
Water-based heat distribution to HIUs
LARGE A-1
Air source heat pumps – Medium temp
LARGE A-2
Air source heat pumps – Low temp to heat pumps
LARGE A-3
Tube exhaust air heat pumps – Medium temp
LARGE A-4
Tube exhaust air heat pumps – Low temp
LARGE G-1
Ground source heat pump – Medium temp
LARGE G-2
Ground source heat pump – Low temp
LARGE W-1
Aquifer heat pump – Medium temp
LARGE W-2
Sewer heat pump – Medium temp
IN
OUT

Low carbon heating tool

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Low Carbon Heating Tool

SYSTEM DESCRIPTION			RECOMMENDED FOR THIS PROJECT		
Option	Scale	System	Flats	Houses	Summary
	Communal	Communal **air source heat pump** with external unit supplying heat at 65˚C. Communal hot water tank.			
	Individual	Individual **combination gas boiler**			
	Individual	Individual **electric radiators** for space heating. Individual **electric hot water tanks** for DHW.			
	Individual	Individual **air source heat pumps** with external unit. Individual hot water tanks.			
	District	District **water source heat pump** supplying heat interface units at 65˚C.			
	Communal	**Communal ground array** supplying individual heat pumps at ambient temperature. Individual hot water tanks.			
	Individual	Individual **exhaust air heat pumps** Individual hot water tanks.			

Considerations

Cost:

-Capital
-Operational

Carbon:

-Embodied
-Operational

Energy use:

-heat loss
-net zero

Space required

Overheating implications

Maintenance & operation

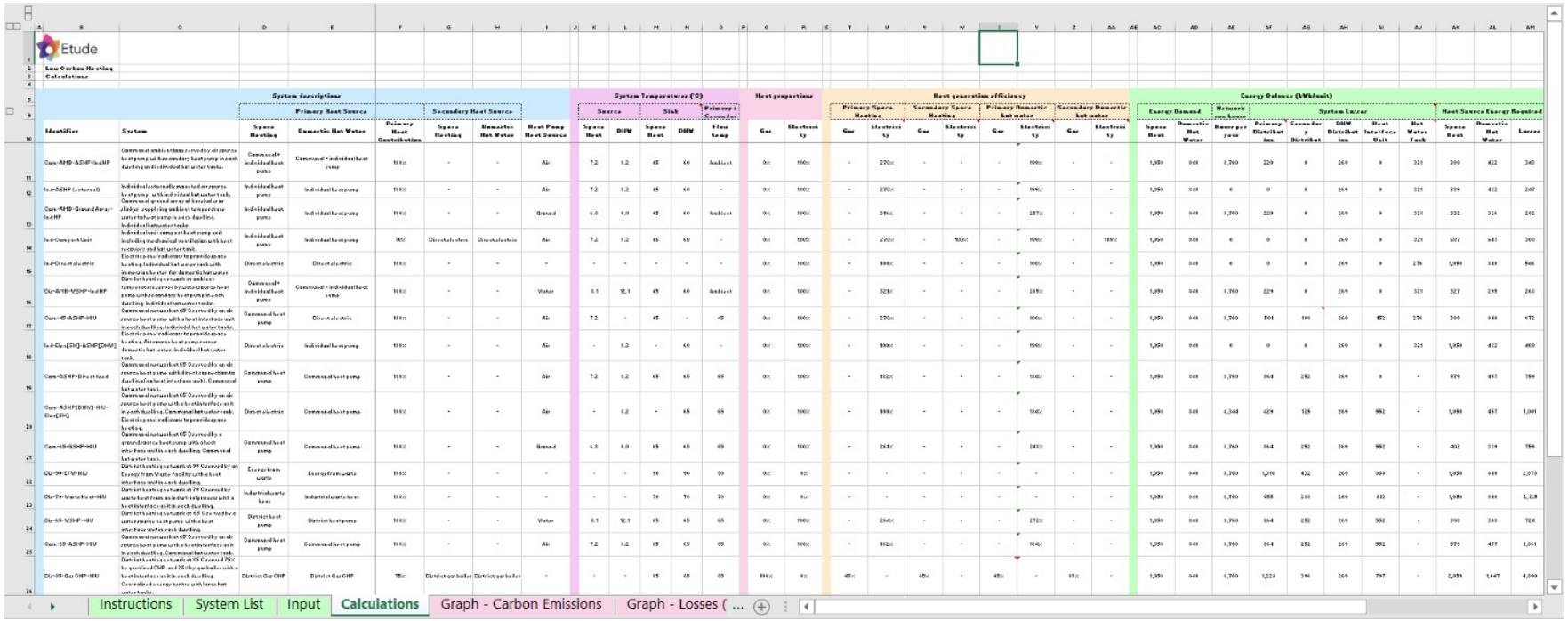
Qualitative approach

- Quick comparison
- Hides the assumptions
- Might not respond to characteristics of the project:
  - efficiency of the building fabric
  - density of dwellings
  - sensitivity to cost

Considerations

	QUALITATIVE ASSESSMENT							KEY SPATIAL REQUIREMENTS					
	Capital cost	Heating costs	Operational carbon emissions	Embodied carbon	Distribution losses	Impact on overheating risk	Impact on infrastructure	Site-wide Energy Centre?	Roof plant on each building?	HIU in each unit?	Heat pump in each unit?	Hot water tank in each unit?	MVHR included?
System A	Low	Medium	Medium	Medium	Medium	High	-		•				
System B	High	Low	Low	Medium	Low	Low	-		•		•	•	
System C	Medium	Low	Low	Medium	Low	Low	-				•	•	
System D	Low	Low	Low	Low	Low	Low	Electricty grid reinformcene t may be required				•	•	
System E	Low	Medium	Medium	Low	Low	Low	Electricty grid reinformcene t may be required					•	

Quantitative analysis



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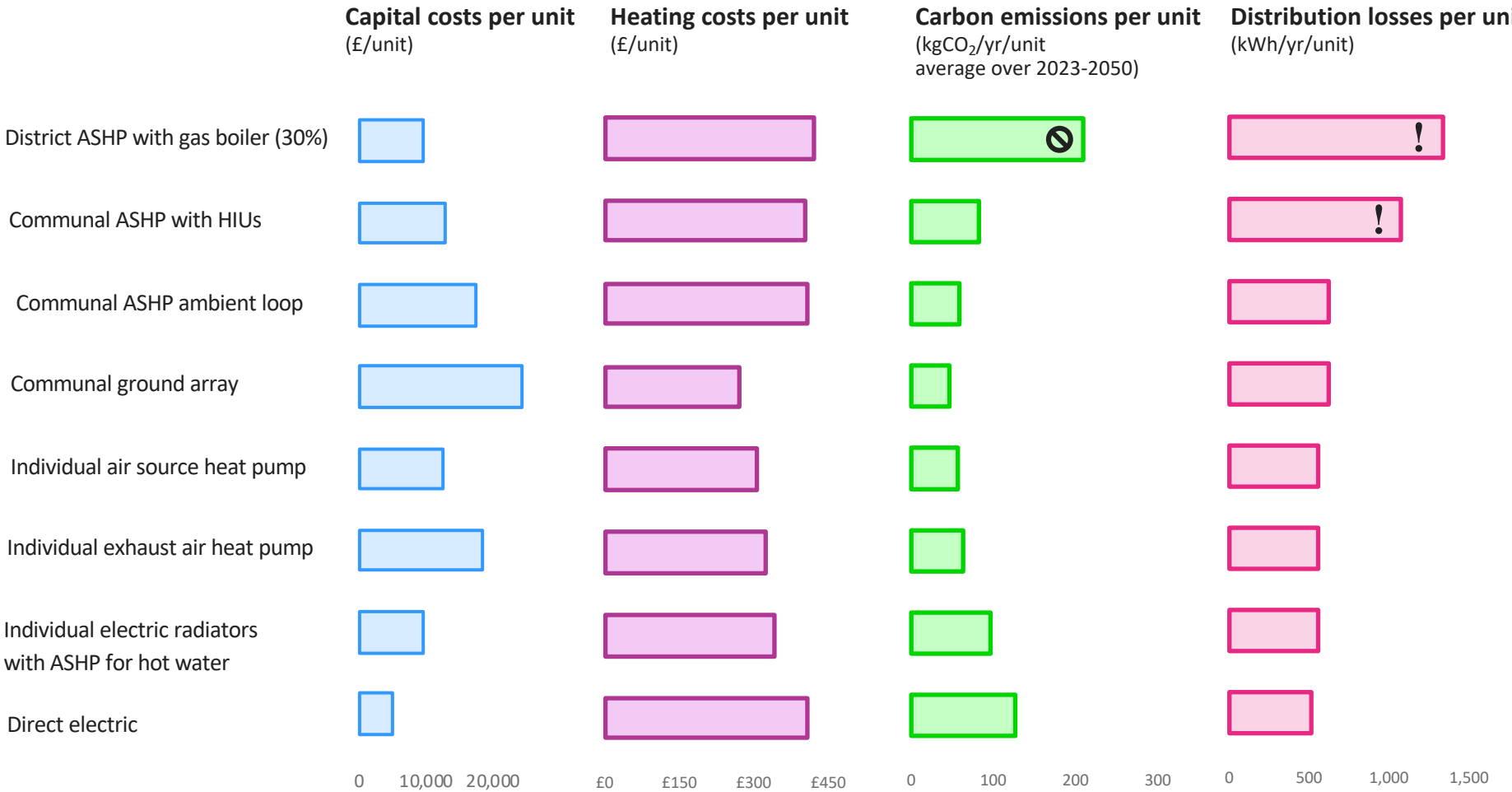
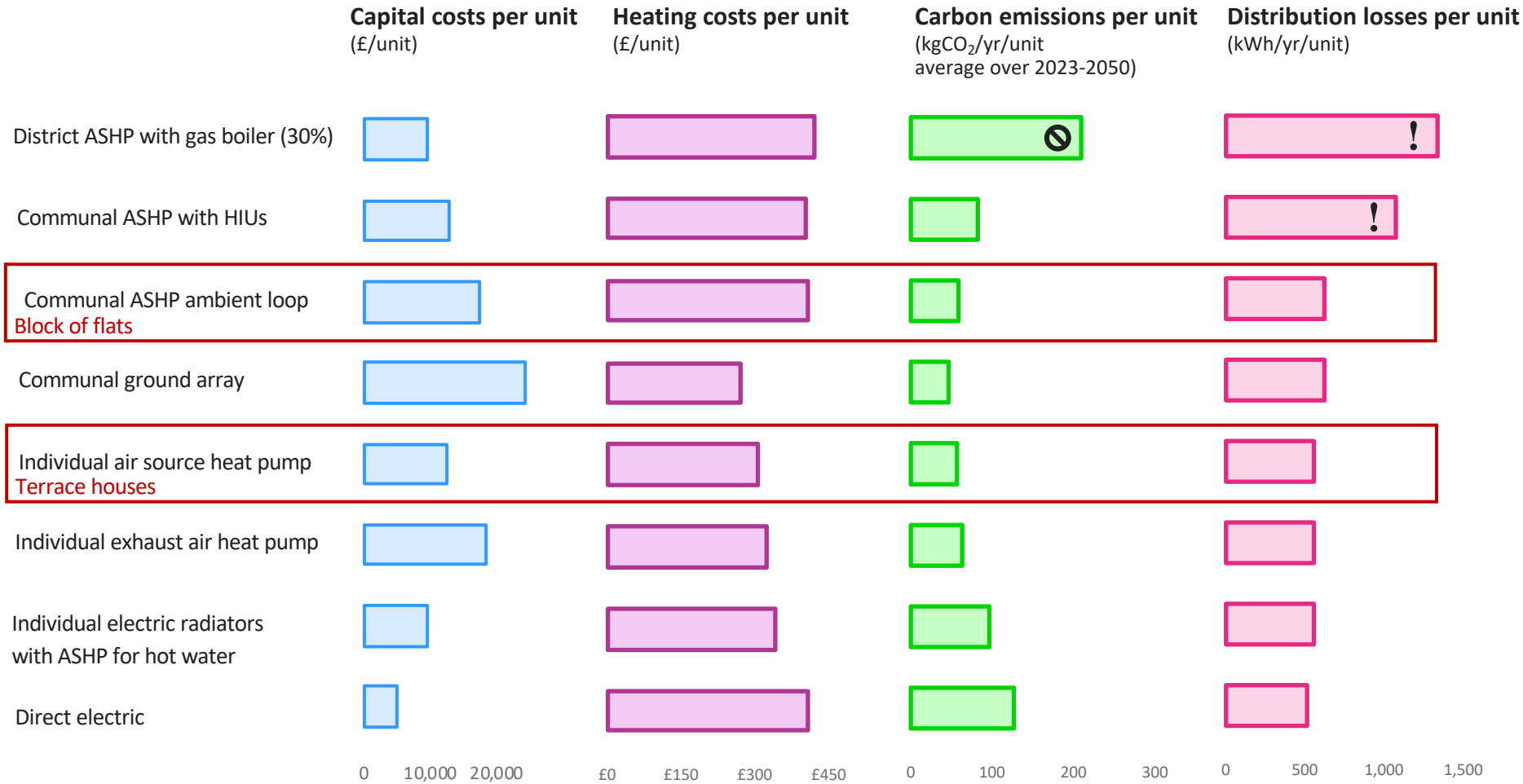
Low Carbon Heating Calculations

		System description							System Temperatures (°C)					Heat proportions		Heat generation efficiency						Energy Balance (kWh/unit)									
		Primary Heat Source			Secondary Heat Source				Source		Sink		Primary / Secondary			Primary Space Heating		Secondary Space Heating		Primary Domestic hot water		Secondary Domestic hot water		Energy Demand		Network pump losses	System Losses					Heat Source Energy Required	
Identifier	System	Space Heating	Domestic Hot Water	Primary Heat Contribution	Space Heating	Domestic Hot Water	Heat Pump Heat Source	Space Heat	DHW	Space Heat	DHW	Flow temp	Gas	Electricity	Gas	Electricity	Gas	Electricity	Gas	Electricity	Space Heat	Domestic Hot Water	Heat per year	Primary Distribut ion	Secondary Distribut	DHW Distribut ion	Heat Interface Unit	Hot Water Tank	Space Heat	Domestic Hot Water	Losses
Com-AHP-ASHP-IndHP	Communal ambient loop served by air source heat pump with secondary heat pump in each dwelling and individual hot water tanks.	Communal + individual heat pump	Communal + individual heat pump	100%	-	-	Air	7.2	12.2	45	60	Ambient	0%	100%	-	270%	-	-	-	300%	-	-	1,050	340	3,700	220	0	260	0	321	200	422	240
Ind-ASHP (external)	Individual external dry mounted air source heat pump, with individual hot water tank.	Individual heat pump	Individual heat pump	100%	-	-	Air	7.2	12.2	45	60	-	0%	100%	-	270%	-	-	-	300%	-	-	1,050	340	0	0	0	260	0	321	339	422	247
Com-AHP-GroundArray-IndHP	Communal ground array all borehole water station, supplying ambient temperature water to heat pumps in each dwelling. Individual hot water tanks.	Individual heat pump	Individual heat pump	100%	-	-	Ground	6.0	8.0	45	60	Ambient	0%	100%	-	39%	-	-	-	257%	-	-	1,050	340	3,700	220	0	260	0	321	332	324	202
Ind-CompactUnit	Individual heat pump heat pump unit including mechanical ventilation with heat recovery and hot water tank.	Individual heat pump	Individual heat pump	70%	Direct electric	Direct electric	Air	7.2	12.2	45	60	-	0%	100%	-	270%	-	100%	-	300%	-	100%	1,050	340	0	0	0	260	0	321	507	547	300
Ind-Direct electric	Electric panel radiator to provide space heating, individual hot water tank with immersion heater for domestic hot water.	Direct electric	Direct electric	100%	-	-	-	-	-	-	-	-	0%	100%	-	100%	-	-	-	100%	-	-	1,050	340	0	0	0	260	0	276	1,050	340	346
DU-AHP-MSHP-IndHP	District heating network at ambient temperature served by water source heat pump with secondary heat pump in each dwelling. Individual hot water tanks.	Communal + individual heat pump	Communal + individual heat pump	100%	-	-	Water	8.1	12.1	45	60	Ambient	0%	100%	-	321%	-	-	-	245%	-	-	1,050	340	3,700	220	0	260	0	321	327	295	260
Com-HP-ADHP-HIU	Communal network at 45°C served by an air source heat pump with a heat interface unit in each dwelling. Individual hot water tanks.	Communal heat pump	Direct electric	100%	-	-	Air	7.2	-	45	-	45	0%	100%	-	270%	-	-	-	100%	-	-	1,050	340	3,700	304	100	260	152	276	300	340	472
Ind-Ele[DH]-ASHP[DHW]	Electric panel radiator to provide space heating, Air source heat pump to our domestic hot water. Individual hot water tanks.	Direct electric	Individual heat pump	100%	-	-	Air	-	12.2	-	60	-	0%	100%	-	100%	-	-	-	100%	-	-	1,050	340	0	0	0	260	0	321	1,050	422	400
Com-ASHP-Direct heat	Communal network at 45°C served by air source heat pump with direct connection to dwelling (no heat interface unit). Communal hot water tank.	Communal heat pump	Communal heat pump	100%	-	-	Air	7.2	12.2	45	45	45	0%	100%	-	102%	-	-	-	104%	-	-	1,050	340	3,700	364	252	260	0	-	579	457	784
Com-ASHP[DHW]-HIU-Ele[DH]	Communal network at 45°C served by an air source heat pump with electric heat interface unit in each dwelling. Communal hot water tank. Electric panel radiators to provide space heating.	Direct electric	Communal heat pump	100%	-	-	Air	-	12.2	-	45	45	0%	100%	-	100%	-	-	-	104%	-	-	1,050	340	4,344	429	125	260	592	-	1,050	457	1,001
Com-45-GSHP-HIU	Communal network at 45°C served by a ground source heat pump with a heat interface unit in each dwelling. Communal hot water tank.	Communal heat pump	Communal heat pump	100%	-	-	Ground	6.0	8.0	45	45	45	0%	100%	-	261%	-	-	-	240%	-	-	1,050	340	3,700	364	252	260	592	-	602	334	784
DU-90-EFW-HIU	District heating network at 90°C served by an Energy from Waste facility with a heat interface unit in each dwelling.	Energy from waste	Energy from waste	100%	-	-	-	-	-	90	90	90	0%	0%	-	-	-	-	-	-	-	-	1,050	340	3,700	1,316	432	260	959	-	1,050	340	2,079
Du-70-Waste Heat-HIU	District heating network at 70°C served by waste heat from an industrial process with a heat interface unit in each dwelling.	Industrial waste heat	Industrial waste heat	100%	-	-	-	-	-	70	70	70	0%	0%	-	-	-	-	-	-	-	-	1,050	340	3,700	955	281	260	612	-	1,050	340	2,025
Du-65-MSHP-HIU	District heating network at 65°C served by a water source heat pump with a heat interface unit in each dwelling.	District heat pump	District heat pump	100%	-	-	Water	8.1	12.1	65	65	65	0%	100%	-	264%	-	-	-	272%	-	-	1,050	340	3,700	364	252	260	592	-	390	380	724
Com-45-ADHP-HIU	Communal network at 45°C served by an air source heat pump with a heat interface unit in each dwelling. Communal hot water tank.	Communal heat pump	Communal heat pump	100%	-	-	Air	7.2	12.2	45	45	45	0%	100%	-	102%	-	-	-	104%	-	-	1,050	340	3,700	364	252	260	592	-	579	457	1,001
DU-85-Gas CHP-HIU	District heating network at 85°C served by gas-fired CHP and 20 bar gas boiler with a heat interface unit in each dwelling. Controlled via energy centre with large hot water tanks.	District Gas CHP	District Gas CHP	75%	District gas boiler	District gas boiler	-	-	-	85	85	85	100%	0%	45%	-	85%	-	45%	-	83%	-	1,050	340	3,700	1,220	396	260	797	-	2,050	1,447	4,099

Instructions | System List | Input | Calculations | Graph - Carbon Emissions | Graph - Losses (...



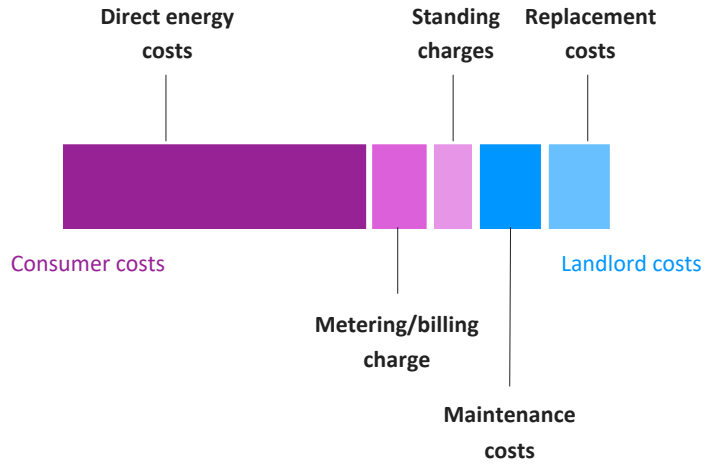

Capital costs per unit
(£/unit)
Heating costs per unit
(£/unit)
Carbon emissions per unit
($kgCO_2$/yr/unit
average over 2023-2050)
Distribution losses per unit
(kWh/yr/unit)
District ASHP with gas boiler (30%)
Communal ASHP with HIUs
Communal ASHP ambient loop
Block of flats
Communal ground array
Individual air source heat pump
Terrace houses
Individual exhaust air heat pump
Individual electric radiators
with ASHP for hot water
Direct electric
0
10,000
20,000
£0
£150
£300
£450
0
100
200
300
0
500
1,000
1,500

Operational cost

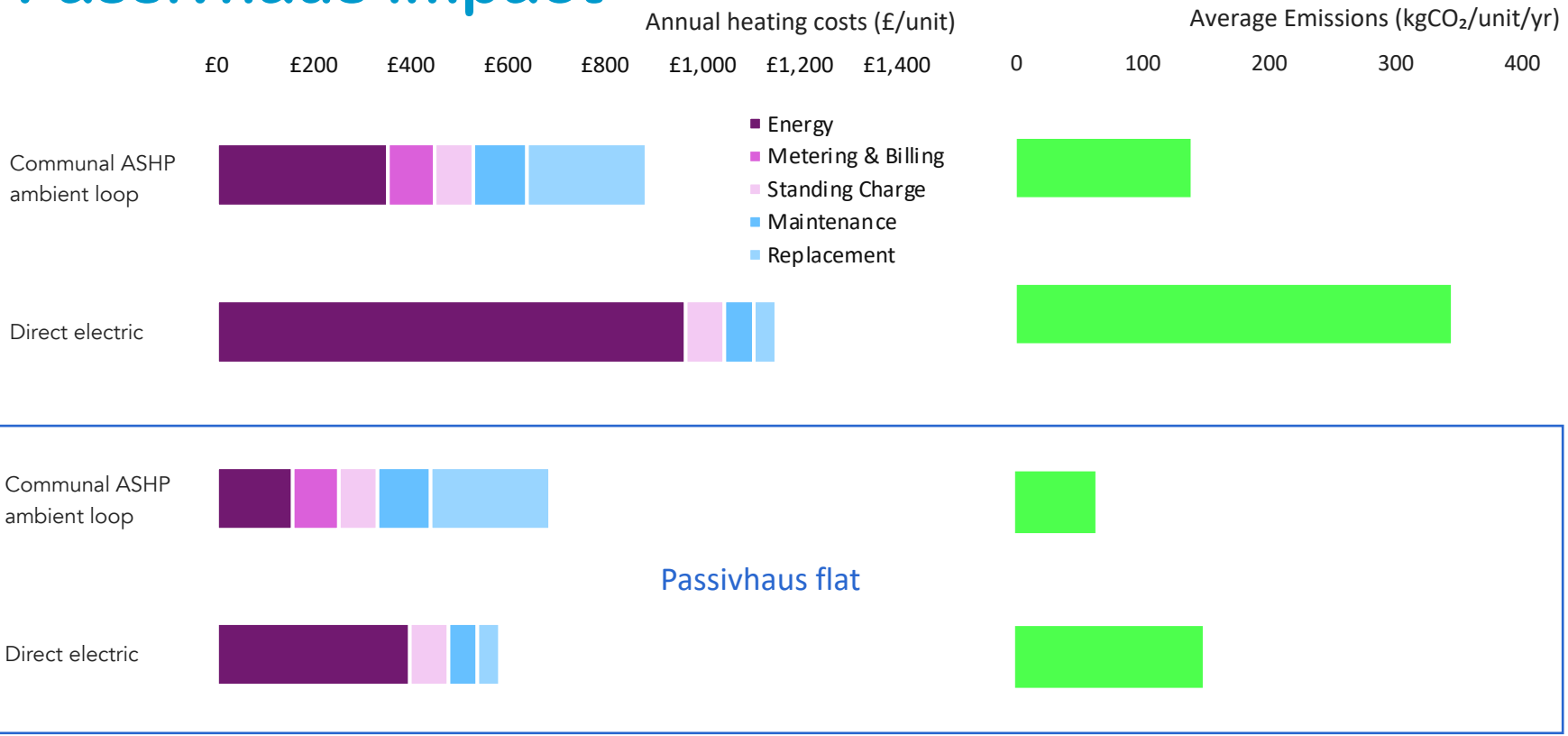
Lots of components

- Communal systems
- Fuel costs vs standing charges
- Social housing

Reporting as a single figure can hide the subtleties



Passivhaus impact



Fuel cost

Electricity is becoming greener, not cheaper

Awareness of fuel poverty

Compared evolution of the carbon content of electricity (**grey line**) and the average price of electricity for domestic consumers (**purple bars**) over the last 10 years.

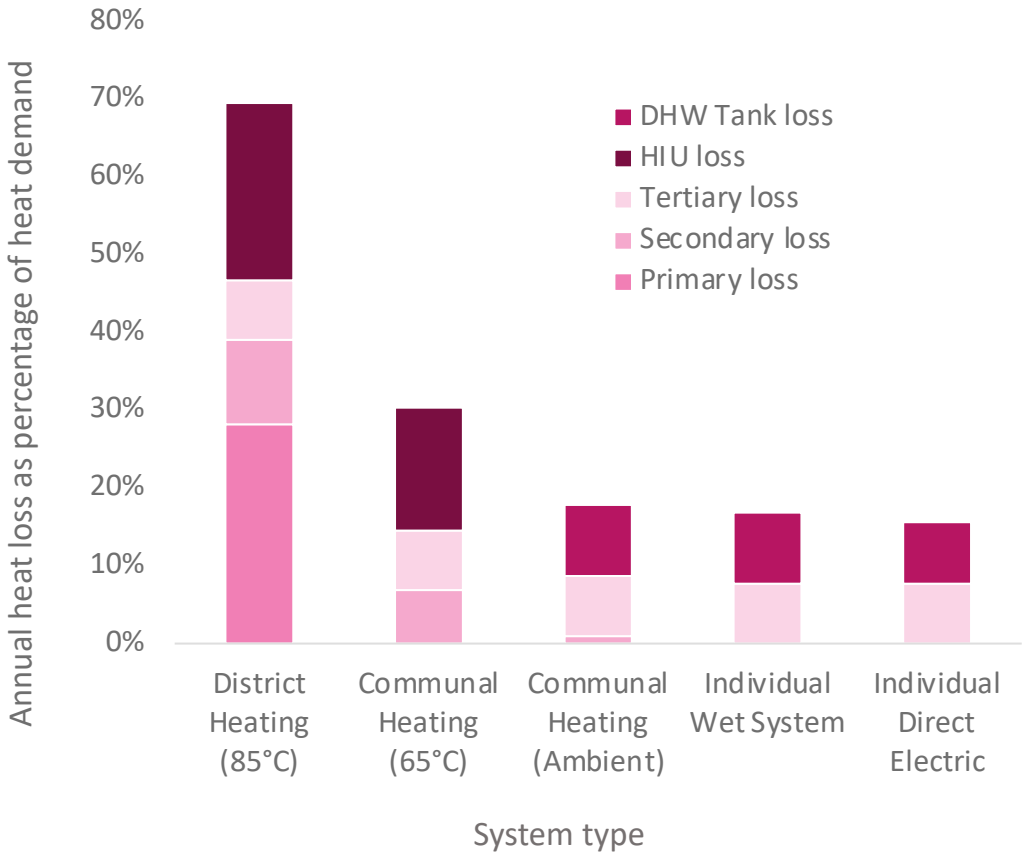
Energy waste

Minimise pipework lengths

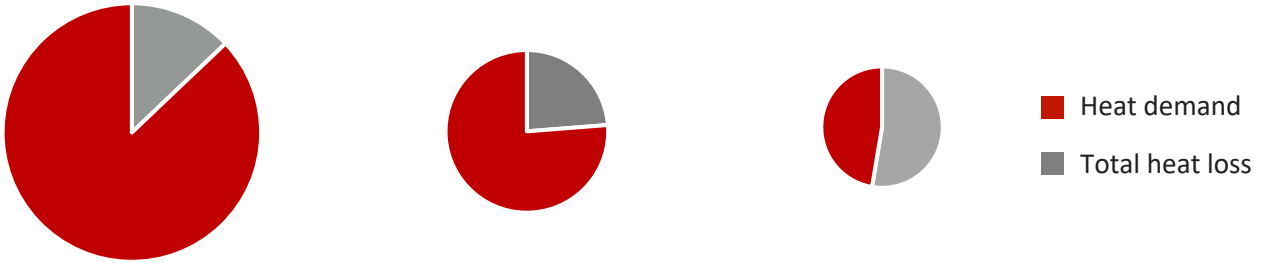
Lower flow temperatures

Insulate pipework

Consider impact on overheating



Passivhaus & energy waste

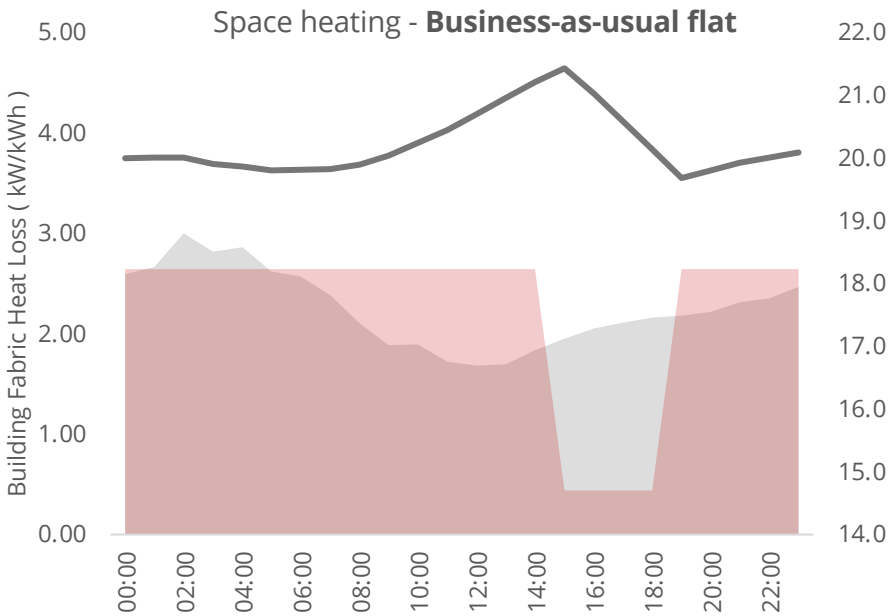


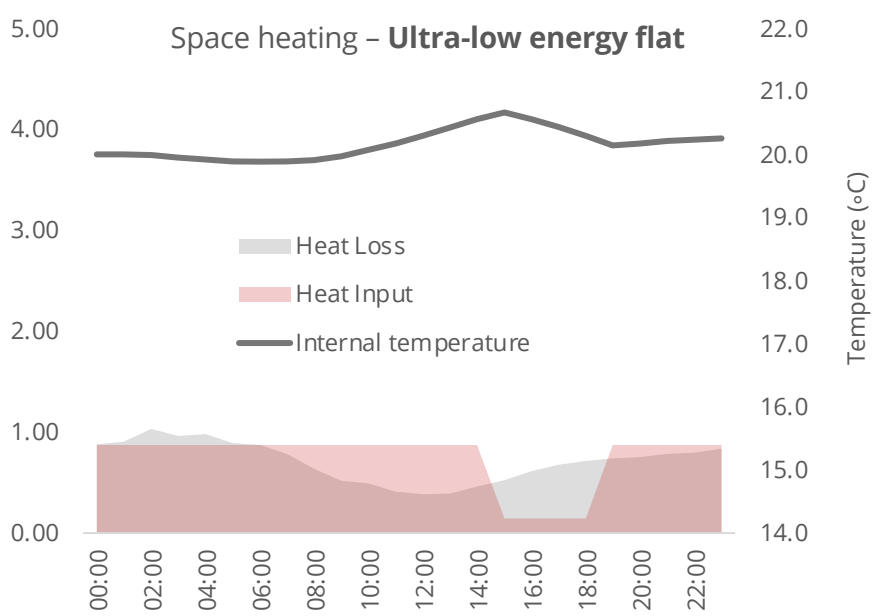
Existing build

New build or refurbishment

Ultra-low energy

Passivhaus & demand flexibility





In summary

- Lots of factors to weigh up, project by project basis
- Many heat pump systems out there, let's start using them
- Designing to Passivhaus may present option for direct electric
- More to understand, embodied energy, performance of heat pumps at low power output

UKpassivhaus conference 2021

DELIVERING NET ZERO THROUGH PASSIVHAUS

THANK YOU

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